Design and demonstration of 1-bit and 2-bit transmit-arrays at V-band frequencies

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Abstract— **This paper presents the design and demonstration of linearly-polarized and circularly-polarized transmit-arrays operating in the 60-GHz band. The arrays are fabricated with standard printed-board technology and are designed with a fairly simple structure using three metal layers. The experimental results show very good performances for both arrays with a gain of 22-23 dBi, a -3 dB gain-bandwidth of 11-13%, and low cross-polarization level.**

I. INTRODUCTION

Many different configurations of transmit-arrays have been proposed using various technologies (laminates, glass) from C- to K-band [4-6]. Reconfigurable arrays based on semiconductor or RF-MEMS devices have also been introduced recently; they exhibit very promising features despite the fabrication complexity of active structures.

To our knowledge, this paper is the first one reporting on transmit-array antennas operating in V-band around 60 GHz. Their fabrication with a standard printed-board technology demonstrates their promising capabilities for low-cost fabrication and integration in vehicles, building or portable terminals for the above-mentioned applications. Both linear and circular-polarization arrays are studied

II. TRANSMIT-ARRAY DESIGN

The design of the linear polarization transmit-array was performed with an analytical model previously presented in [6] and using the results of electromagnetic simulations of the focal source (radiation pattern) and the unit-cells (S-parameters and radiation patterns). The simulation results show that maximum gain values of about 23 dBi are obtained for F/D ~ 0.5-1, as a result of trade-off between amplitude taper losses and spill-over losses which are decreasing and increasing respectively with the focal distance.

A circular-polarization transmit-array was designed using the four linearly-polarized unit-cells (sequential rotation). In this design, the four unit-cells correspond to four transmission phase states, 90° apart (2-bit design), with respect to a circular polarization.

A prototype has been fabricated with F/D = 0.5, the computed directivity and gain are 24.7 dBi and 22.1 dBi respectively, corresponding to an efficiency of 55.5%.

A maximum gain of 22 dBi is reached at 61.5 GHz. The simulated and measured -3 dB gain-bandwidth are 6.6 GHz (11%) and 8.2 GHz (13.3%) respectively. The cross-polarization level is below -15 dB across the whole bandwidth.

A good agreement between simulation and measurement is obtained with a beamwidth of 7°/6.75° (sim./meas.). Sidelobe levels are -20 dB/-16 dB (sim./meas.).

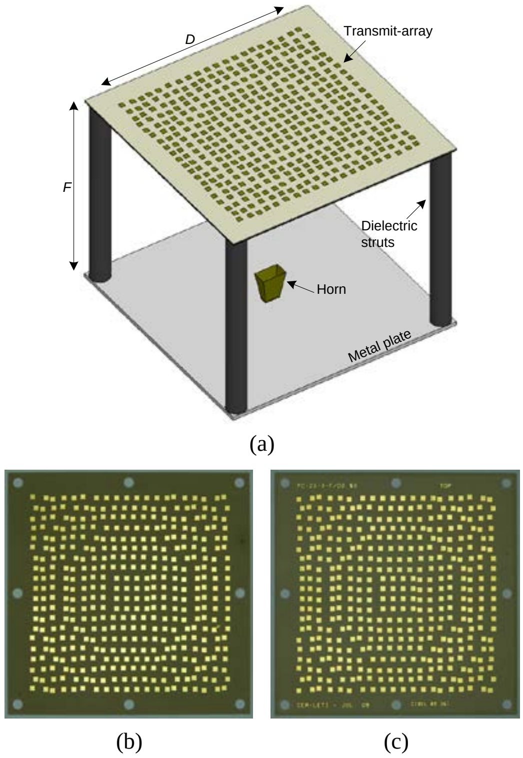

Fig.1 Perspective view of the transmit-array antenna (a), top view (b) and bottom view (c) photographs of the broadside-beam transmit-array.

III. CONCLUSIONS

Two 60-GHz transmit-arrays have been designed in linear and circular polarization. They are fabricated with standard printed-board technology and materials. Gain levels of about 22-23 dBi have been demonstrated with an array aperture of $10\lambda_0\times10\lambda_0$ and a 10 dBi focal source. Their wide bandwidth (11-13%) makes them very appropriate for high-data rate communications in V- and E-bands. Another significant advantage demonstrated with these structures is the possibility to generate very good circular polarization quality from a simple linearly-polarized focal source.